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Habitat Preference of Tabanid Flies in Hokkaido Based upon the Collection of Female Adults[1)]

By

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(With 7 Text-figures and 4 Tables)

Although a good number of papers concerning various aspects of tabanid ecology have hitherto been published in Japan, the precise studies on their ecological distribution or habitat preference have relatively been ignored. The present paper deals with the habitat preference of the haematophagous species inhabiting Hokkaido, based upon the collection of female adults made at forest and openland habitats in four localities (cf. Fig. 1). The results are discussed in relation to the habitat of immature stages. Some assumptions on the allogenic succession of the tabanid assemblage in Hokkaido are also presented linked with an ever increasing environmental change by human impact.

Before going further, cordial thanks are expressed to Prof. Mayumi Yamada and Dr. Shôichi F. Sakagami, Zoological Institute, Hokkaido University, Sapporo, for their guidance and reading through the manuscript. I am also indebted to Dr. Hirosi Takahasi, Ground Self-Defense Force Medical School, Tokyo, who gave me valuable suggestions. The special appreciation is due to Mr. Michiya Yamamoto, a member of our laboratory, and my wife Rei Inaoka for their helps in collecting materials. I wish to express my sincere gratitude to Dr. Mitsuru Maeda, Hokkaido Branch, Government Forest Experiment Station, Sapporo, and to Mr. Yosuo Adachi, Eniwa National Forestry Office, Eniwa, who kindly allowed me the use of the climatic and vegetational data in the area studied.

Methods

Three kinds of collecting methods were employed. I. Triangular trap invented by Hayakawa (Hayakawa, 1970, cf. Fig. 2-a). The sampling was made by two procedures. A) Collecting the specimens attracted on and around the trap skirt by using an insect net of 42 cm in diameter. B) Collecting the specimens invaded into the cage. A unit sample (A+B) was taken for 30 min. and the subsamples A and B were separately preserved. II. Rectangular nylon trap deviced by myself (cf. Fig. 2-b). Only the specimens entered within the trap were collected. Dry ice was used as attractant in these two methods. III. Collecting

1) Ecological Studies on the Family Tabanidae in Hokkaido, II.

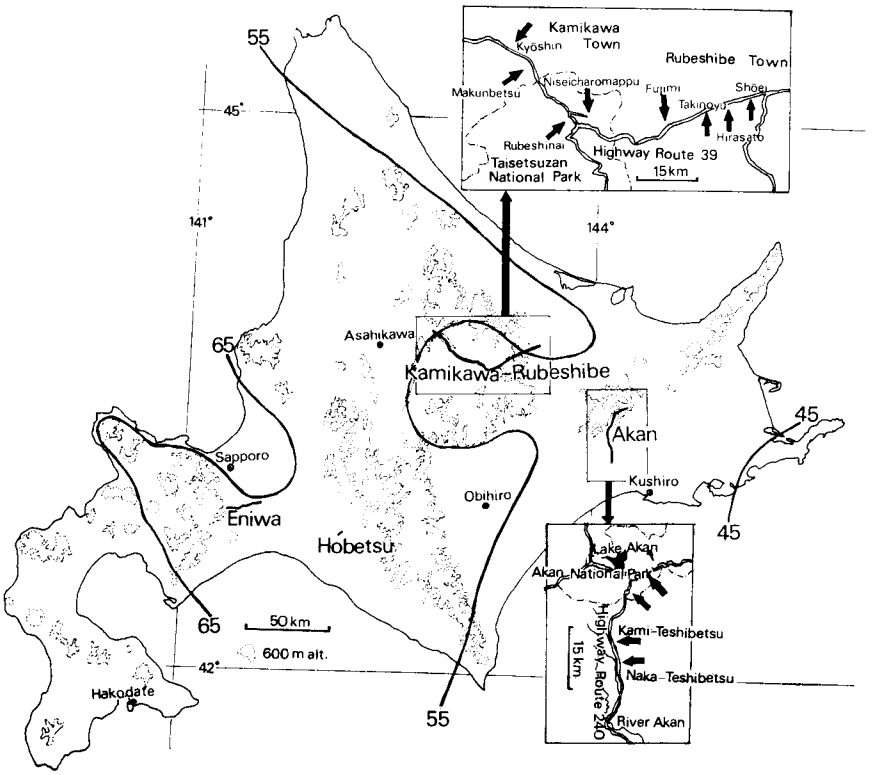

Fig. 1. Map of Hokkaido, indicating the areas surveyed with isothermal lines by warmth index (cited from Shiokawa 1971).

the specimens attracted on and around the car. Although so far not intentionally adopted, this method was proved very effective in collecting various tabanid species. A precise comparison of the results obtained by three aforementioned methods will be given in a separate paper, but the difference was virtually negligible.

The species were identified by Murdoch and Takahasi (1969) except *Hybomitra lapponica* (Wahlburg) which was cited as *Hy. borealis* (Fabricius) according to Chavála and Lyneborg (1970).

Results

1. Observations in Eniwa.

The principal survey was made in Eniwa city located at the western central Hokkaido with the climatic conditions Dfb (Köppen) or A''_3 (Kira). The fluctuation of daily mean temperature and precipitation from June to September,

Fig. 2. Traps employed, a: triangular trap (method I), b: rectangular nylon trap (method II).

1973 in the area studied are given in Fig. 4 cited from the measurements taken at Eniwa National Forestry Office. The original vegetation principally consists of deciduous broad leaf trees, *Quercus crispula*, *Tilia japonica*, *Betula Ermani*, *B. Maximowicziana*, and *Acer Miyabei* are dominant, *Fraxinus mandshurica*, *Ulmus Davidiana* var. *japonica*, *U. laciniata*, *Phellodendron amurense*, *Kalopanax septemlobus*, *Magnolia obovata*, *Alnus japonica*, *Sorbus commixta* and *Salix Bakko* are common, with sparse admixture of conifers, *Picea jezoensis*, *P. Glehni*, *Abies sachalinensis* var. *Mayriana* and *Taxus cuspidata*. The forests in the area studied have partly been afforested by *Lalix leptolepis*, *A. sachalinensis* var. *Mayriana*, *P. jezoensis* and *P. Glehni*. In the deforested areas, the lands are used as pastures, paddy fields and urban areas (cf. Fig. 1 and 3).

1. 1. Phenology: Phenology or seasonal distribution was observed from June 5 to September 11, 1973, by collecting the flies at various places of Eniwa covering different habitats, made for 27 days with irregular intervals. The phenological sequence of all species collected in the area studied is shown in Fig. 4, involving 17 out of 34 species recorded from Hokkaido. Collecting in mid summer was made at various habitats with different intensities e. g. more frequently in forests. The results given in Fig. 4 is therefore slightly biased and incomplete. From the succession of various species, however, the tabanid season covering June to early September is divided into three phases. 1) Early phase, from early June to early July: Started by the earliest species *Chrysops japonicus* with scarce number and short active period, followed by *C. suavis*, the predominant species in the phase, *Hybomitra distinguenda* and *Tabanus kinoshitai*. The tabanid activity is still low. The number of individuals collected occupied only ca. 11% of the total individuals. 2) Major phase, from mid July to eary August: The major active period with the

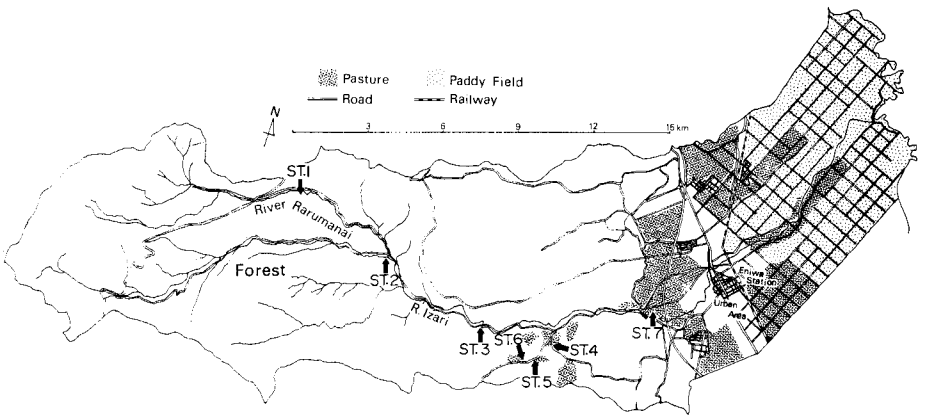

Fig. 3. Map of Eniwa city indicating seven stations.

Species \ Month	June E	June M	June L	July E	July M	July L	August E	August M	August L	September E	September M	September L	Collected Number
Chrysops japonicus Wiedemann	—												6
Hybomitra distinguenda (Verrall)													86
Tabanus kinoshitai Kono et Takahasi													181
Chrysops suavis Loew													478
Tabanus nipponicus Murdoch et Takahasi													194
Tabanus trigeminus Coquillett													128
Haematopota tristis Bigot													8,942
Tabanus pallidiventris Olsoufiev													35
Tabanus sapporoenus Shiraki													46
Atylotus horvathi (Szilady)													27
Tabanus chrysurus Loew													98
Hybomitra borealis (Fabricius)													2
Hybomitra olsoi Takahasi													3
Tabanus iyoensis Shiraki													404
Tabanus rufidens (Bigot)													254
Tabanus sapporoensis Shiraki													474
Tabanus fulvimedioides Shiraki													2
Daily mean temperature and precipitation	20°C	10°C		temp.			precip.						80mm 40mm

Fig. 4. Phenological sequence of tabanid species in Eniwa city together with the fluctuation of daily mean temperature and precipitation.

highest numbers of species and individuals, about 82% of total individuals collected. *T. nipponicus* and *Haematopota tristis* are predominant in pastures and forests respectively. 3) Late phase, from mid August to early September: Tabanid activity rapidly decreaseed with only 7% of the total individuals collected. *T.*

rufidens is predominant.

1. 2. Habitat preference: For the analysis of specific preference, periodical sampling was made by using method II on July 14, 26 August 8, 14, 25 and September 4, 11 at seven stations. Although the early phase was only incompletely covered, it does not seriously affect the total collection data for the low activity in that period. A periodical sampling was started on 10: 00 by setting dry ice into the first trap and finished on 15:00 by removing the attractant and flies from the last trap, with the schedule conveniently determined by transport facility among stations as follows:

Station	Dry ice setting	Dry ice and flies removal	Station	Dry ice setting	Dry ice and flies removal
1	10:00	13:00	5	11:25	14:25
2	10:30	13:30	6	11:35	14:35
3	10:45	13:45	7	12:00	15:00
4	11:10	14:10			

The difference in weather conditions at different sampling time among stations was virtually negligible on fine and calm summer days. The conditions of seven stations are briefly described: Sts. 1, 2 and 3 are in a forest facing the Rarumanai or Izari river with altitude 280 m, 220 m and 180 m respectively. Traps were set at the places where the sun beams reached the ground through the tree canopy, as already verified by a preliminary test that few flies were attracted to traps set at the complete shade. Sts. 4, 5 and 6 are in the transitional zone between forest and pasture, alt. 170 m, 160 m and 180 m respectively, choosing forest edges facing pastures. St. 7 is on a large pasture, alt. 90 m. Trapping site was in the sparse hedge near a cattle shed (cf. Fig. 3). While the number of species did not much differ among stations, the number of individuals was much more abundant at the stations in the forest than in other habitats (Table 1). The data obtained from similar habitat types were combined (St. 1～3, St. 4～6, St. 7), and converted to the percentage ratios in Fig. 5 and given with the upper and lower fiducial limits ($p=0.05$), applying the occurrence probability method (Kato *et al.* 1952). From Table 1 and Fig. 5, the distribution by habitat of each species is described below. The distribution pattern according to the uneveness of abundance among habitats, F(Forest), P(Pasture) and FP(Transitional zone between F and P), is added to in the bracket.

Ha. tristis was found in all stations but not uniformly distributed, showing a remarkable preference for forest habitat [F>FP>P] ($p<0.05$). *T. iyoensis* collected only at forest stations is regarded as a stenotopic sylvicolous species. *T. sapporoensis* was common in forest stations decreasing conspicuously in the other habitats. But the relative abundance between F and FP was not significantly different, suggesting its not strictly sylvicolous nature [F≥FP($p<0.05$)>P(absent)]. These three species indubitably prefer forests than other habitats. *C. suavis* and *T. kinoshitai* are ubiquitous in all stations with uniform distribution [F≒FP≒P] ($p>0.05$). *T. sapporoenus* and *T. chrysurus* behave similarly thought not recorded

Table 1. Capture records at seven stations with percentage ratios in parentheses

Habitat type and St. No. / Species	Forest			Transitional zone between Forest and Pasture			Pasture	
	St. 1	St. 2	St. 3	St. 4	St. 5	St. 6	St. 7	Total
Haematopota tristis	118 (81.4)	306 (84.8)	165 (82.1)	31 (23.2)	59 (68.6)	28 (29.8)	9 (9.5)	716
Tabanus iyoensis	2 (1.4)	13 (3.6)	5 (2.5)					20
T. sapporoensis	3 (2.1)	11 (3.1)	4 (2.0)	1 (0.7)		1 (1.1)		20
Chrysops suavis	11 (7.6)	10 (2.8)	6 (3.0)	5 (3.6)	3 (3.5)	5 (5.3)	5 (5.3)	45
T. kinoshitai	4 (2.8)	2 (0.6)	2 (1.0)	4 (2.9)	2 (2.3)	2 (2.1)	4 (4.2)	20
T. sapporoenus		3 (0.8)	2 (1.0)	5 (3.6)	1 (1.2)	1 (1.1)	1 (1.1)	13
T. chrysurus		3 (0.8)		2 (1.5)		2 (2.1)	1 (1.1)	8
T. trigeminus		5 (1.4)	4 (2.0)	5 (3.6)	2 (2.3)	6 (6.4)		22
Hybomitra distinguenda	1 (0.7)		1 (0.5)	10 (7.5)	5 (5.8)	6 (6.4)	1 (1.1)	24
T. rufidens	4 (2.8)	6 (1.7)	5 (2.5)	29 (21.6)	6 (7.0)	21 (22.3)	10 (10.5)	81
T. nipponicus	1 (0.7)	2 (0.6)	6 (3.0)	31 (23.2)	6 (7.0)	18 (19.2)	48 (50.5)	112
T. pallidiventris				3 (2.2)	1 (1.2)	1 (1.1)	6 (6.3)	11
Atylotus horvanthi			1 (0.5)	8 (6.0)	1 (1.2)	3 (3.2)	10 (10.5)	23
Hy. olsoi	1 (0.7)							1
Total	145	361	201	134	86	94	95	1,116
Number of species	9	10	11	12	10	13	10	14

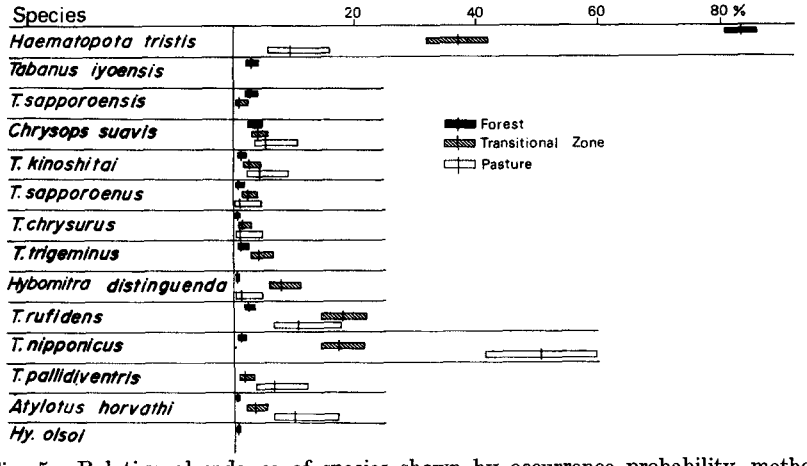

Fig. 5. Relative abundance of species shown by occurrence probability method at each habitat in Eniwa. Percentage ratios in forests, transitional zone (forest~pasture) and pasture are given by short vertical lines on respective horizontal bars indicating fiducial limits.

in some stations [F≒FP≒P]. These four species could be regarded as eurytopic. Some species, *T. trigeminus*, *Hy. distinguenda* and *T. rufidens* are characterized by the abundance at the transitional zone, especially in Sts. 4 and 6 [FP>F>P], [FP>F≒

P] and [FP≥P>F]. It is difficult to determine their habitat preference, but I assume them as essentially eurytopic. *T. nipponicus*, *T. pallidiventris* and *Atylotus horvathi* occur in relatively large number in pastures, decreasing rapidly as the distance from pasture increases [F<FP<P], showing their strong preference for habitats in or near pastures. Besides sampling at seven stations, sporadical collections were made by method III in and near Eniwa. Tabanid assemblage collected by this method in forests well agreed with those of Sts. 1~3 in relative abundance. Out of 235 flies collected from eight places in forest habitats, *Ha. tristis* was predominant (86.7%) followed by *C. suavis*, *T. sapporoensis*, *T. chrysurus*, *T. trigeminus*, *T. kinoshitai*, *T. sapporoenus*, *T. rufidens*, *Hy. olsoi* and *T. nipponicus* in the descending order. Some horse-flies were collected by method III in paddy fields and urban areas such as graveyard, school ground and even in front of Eniwa Railway Station near the center of the city. Although the individual number was obviously low, the relative abundance of species were similar to that obtained by method II at St. 7. Among 85 flies collected from nine places in such habitats, *T. nipponicus* was predominant (40 %) followed by *T. pallidiventris* (22.4 %), *C. suavis*, *Ha. tristis*, *A. horvathi*, *T. rufidens*, *T. kinoshitai*, *T. sapporoenus*, *T. trigeminus* and *T. chrysurus*. The similarity of tabanid assemblage between pastures (St. 7) and paddy fields or urban areas indicates that the pasture species such as *T. nipponicus*, *T. pallidiventris* and *A. horvathi* are tolerable to man-made openland habitats, so that they are regarded as openland species against forest or eurytopic ones. The habitat preference of rare species cannot be determined. In the area studied, *C. japonicus*, *Hy. borealis*, *Hy. olsoi* and *T. fulvimedioides* belong to this category.

2. Comparison of tabanid assemblages between forest and openland habitat in other districts in Hokkaido.

The aims of this section are to verify the result obtained in Eniwa and to determine the habitat preference of some species which were absent or very rare in Eniwa.

2. 1. Relative abundandance of tabanid species in forest and openland habitat in Hobetsu town: Hobetsu town situates about 30 km southeast from Eniwa city (cf. Fig. 1). Horseflies were collected on July 20 and August 11, 1972, in forest, on July 19 and August 11 in openland habitat by using triangular trap (method I). Most species collected in Hobetsu were common to those in Eniwa with the exception of *C. vanderwulpi*. The resemblance of tabanid fauna between both localities is understood by the short distance between two localities and climatic as well vegetational similarities. The relative abundance in percentage ratios of species arranged in the order same to Fig. 5 is given with upper and lower fiducial limits in Fig. 6. As collecting effort was different at various habitats so that the number of flies collected at forest and openland habitat are not directly comparable. According to the unevenness of relative abuncance between forest and openland

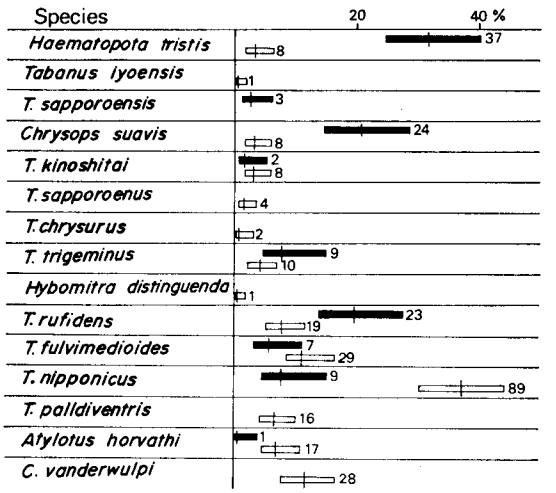

Fig. 6. Relative abundance of species at forest and openland habitat in Hobetsu. Numerals give the number of collected individuals. Further explanations shown in Fig. 5.

habitats, the species are divided into three preference types.

Forest species, [F (Forest)>P (Openland)] ($p<0.05$) ..... *Ha. tristis*, *C. suavis* and *T. rufidens*.

Eurytopic species, [F≒P] ($p>0.05$)..... *T. kinoshitai*, *T. trigeminus* and *T. fulvimedioides*.

Openland species, [F<P] ($p<0.05$)..... *T. nipponicus*, *T. pallidiventris*, *A. horvathi* and *C. vanderwulpi*.

The preference type of the species collected less than five individuals, *T. iyoensis*, *T. sapporoensis*, *T. sapporoenus*, *T. chrysurus* and *Hy. distinguenda* cannot be determined. In most species, the habitat preference in Hobetsu and Eniwa shows the same trends with two exceptions, *C. suavis* and *T. rufidens*. They were classified in eurytopic species in Eniwa, while showing a considerable preference for forest habitat in Hobetsu. This discrepancy suggests the unstability of habitat preference of some eurytopic species. *T. fulvimedioides* and *C. vanderwulpi*, both very rare in Eniwa, were classified in eurytopic and openland species respectively.

2. 2. Survey in Akan town: Akan town in eastern Hokkaido is characterized by cold climate and low precipitation throughout the year. Dairy farming flourished remarkably in Teshibetsu area in the town where a plenty of large pastures has been established. The northern part of the town is included in Akan National Park where the original coniferous vegetation is relatively well preserved. On July 22 and August 13, 1972, horse-flies were collected by method I at two places in a forest in National Park and on the pastures in Naka- and Kami-Teshibetsu (cf. Fig. 1). Collection data are shown in Table 2 with percentage

Table 2. Capture records of tabanid flies in Akan town with percentage ratios in parentheses

Habitat type	Large pasture		Forest of conifers	
Locality & Altitude / Species	Naka-Teshibetsu 110 m	Kami-Teshibetsu 180 m	Akan National Park, 360 m	Akan National Park, 450 m
Haematopota tristis	7(20.0)	13(25.5)	15(100.0)	19(95.0)
Ha. tamerlani	2 (5.7)	2 (3.9)		
Chrysops suavis	1 (2.9)	1 (2.0)		
Tabanus chrysurus		1 (2.0)		1 (5.0)
T. trigeminus	1 (2.9)			
Hybomitra olsoi	1 (2.9)	4 (7.8)		
T. nipponicus	23(65.7)	30(58.8)		
Total	35	51	15	20

ratios in parentheses. In spite of a poor number of collected individuals due to adverse weather conditions, an overwhelming predominance of *Ha. tristis* in forest habitat is obvious. Further it is noteworthy that this species was relatively abundant, too, in openland habitat, occupying the second rank following the typical openland species, *T. nipponicus*.

2. 3. Survey in Rubeshibe and Kamikawa towns: Tabanid assemblage was surveyed in Rubeshibe and Kamikawa towns situated on the hilly and mountainous region of eastern central Hokkaido, characterized by very cold winter and relatively favorable but short summer. Horse-flies were collected by using method I in four places in Rubeshibe town and three in Kamikawa on July 24, 1972. On the same date in 1973, a more intensive survey was made by using methods I, II, III in Niseicharomappu forest in Kamikawa (cf. Fig. 1). The habitat type and altitude of each trapping site are mentioned in Table 3 with capture records. *Ha. tristis* was terribly numerous around the trap and collector in the mountainous forests in Kamikawa. At the highest trapping site in Niseicharomappu forest, *Ha. tamerlani* was top ranked followed by *Ha. tristis*. The openland species such as *T. nipponicus*, *T. pallidiventris* and *C. vanderwulpi* were completely absent in forest areas, nevertheless, *T. nipponicus* has always occupied the top rank in openland habitats in most surveys so far undertaken throughout Hokkaido. The relative abundance of *Ha. tristis* was significantly different in openland habitat between Rubeshibe (eastern side) and Kamikawa (western side). In the former, it occupied the second rank or 27.6% as in Akan town, while in the latter only 3.7% as in Eniwa or Hobetsu. Two species belonging to *Hybomitra*, *Hy. tarandina* and *Hy.* sp., seemingly prefer mountainous forests. *Hy. olsoi* was found only in forests in the present survey while only in openlands in Akan. A similar disparity was recognized in the distribution of *Ha. tamelrani*. More precise studies are required to give a definitive statement on the habitat preference of these species.

Table 3. Capture records of tabanid flies in Rubeshibe and Kamikawa town with

Town	Rubeshibe		
Habitat type	Large pastures		
Locality & Altitude	Shôei	Hirasato	Takinoyu
Species	240 m	280 m	360 m
Haematopota tristis	4(28.6)	6(22.2)	6(35.3)
Ha. tamerlani		1 (3.7)	1 (5.9)
Chrysops suavis		3(11.1)	
Tabanus kinoshitai			2(11.8)
T. sapporoenus			
T. chrysurus		4(14.8)	
T. trigeminus		2 (7.4)	
Hybomitra distinguenda			
Hy. olsoi			
Hy. sp.			
Hy. tarandina			
Hy. borealis			
T. nipponicus	5(35.7)	11(40.7)	8(47.1)
T. pallidiventris	5(35.7)		
C. vanderwulpi			
Total	14	27	17

Finally the habitat preference of 21 species collected by the survey are summarized.

1. Forest species: *Ha. tristis*, *T. iyoensis*, *T. sapporoensis*, *Hy. tarandina* and *Hy.* sp.

2. Eurytopic species: *C. suavis*, *T. kinoshitai*, *T. sapporoenus*, *T. chrysurus*, *T. trigeminus*, *Hy. distinguenda*, *T. rufidens* and *T. fulvimedioides*. These species do not show a distinct preference tendency within the limits of the present knowledge. Further studies might reveal their weak preference to some habitats.

3. Openland species: *T. nipponicus*, *T. pallidiventris*, *A. horvathi* and *C. vanderwulpi*.

4. Species habitat preference of which is still uncertain: *C. japonicus*, *Hy. borealis*, *Hy. olsoi* and *Ha. tamerlani*.

Discussion

The precise study of habitat preference or ecological distribution of tabanid species based upon the female adult collection has not so far been made in Japan, but several papers on the tabanid faunal makeup in some localities in Honshu presented short comments of habitat types in the areas observed. (Abe *et al.* 1955, Otsuru *et al.* 1956 and 1965, Wakuri *et al.* 1958 and 1959, Maki 1965, Shimizu *et al.*

percentage ratios in parentheses, surveyed in 1972 except Niseicharomappu, (1973)

	Kamikawa			
Pasture in forest	Mountainous forests of conifers			Pasture in paddy field
Fujimi 500 m	Nisei-charomappu 1,100 m	Rubeshinai 750 m	Makunbetsu 520 m	Kyôshin 340 m
123 (79.4)	212 (26.9)	223 (86.4)	53 (74.6)	2 (3.7)
10 (6.5)	358 (45.4)	8 (3.1)		
1 (0.6)	137 (17.4)	19 (7.4)	4 (5.6)	3 (5.6)
	20 (2.5)	1 (0.4)	1 (1.4)	11 (20.4)
	4 (0.5)		2 (2.8)	5 (9.3)
	5 (0.6)		7 (9.9)	1 (1.9)
	1 (0.1)		4 (5.6)	9 (16.7)
	3 (0.4)			1 (1.9)
	38 (4.8)	4 (1.6)		
	4 (0.5)	3 (1.2)		
	5 (0.6)			
	1 (0.1)			
5 (3.2)				16 (29.6)
				3 (5.6)
				3 (5.6)
155	788	258	71	54

1966, Nagasawa 1967, Sasakawa *et al.* 1968, Hasegawa *et al.* 1970, Hara 1973, Hukushima *et al.* 1973). The distribution and abundance of some species are briefly documented by using the references cited above in comparison with those in Hokkaido described in the present paper.

Among forest species, *T. iyoensis* is most famous by the tremendous outbreak in mountainous forests along deep valleys in several localities in Honshu. A sudden burst was previously recorded in southern Hokkaido (Kono *et al.* 1940) but such case has not recently been recognized in Hokkaido. *T. sapporoensis* is widely distributed mainly in forest areas but it is relatively scarce in northern and central Honshu, only once recorded as a dominant species (Shimizu *et al.* 1966).

Most eurytopic species, i. e. *C. suavis*, *T. kinoshitai*, *T. sapporoenus*, *T. chrysurus* and *T. rufidens* are rather uniformly distributed at various habitat types in Honshu. However, *T. trigeminus* is often predominant in and near paddy fields or pastures, showing a considerable preference for openlands.

Inaoka (1974) showed that *T. nipponicus* is top ranked at openlands throughout Hokkaido and ubiquitously abundant at similar habitat in northern Honshu. On the other hand, a closely allied species, *T. pallidiventris* is relatively rare in Hokkaido except in a few places in central district where it outnumbers *T. nipponicus*. This species has been recorded very sporadically from Honshu. *A. horvathi* and *C. vanderwulpi* widespread in pastures and other type of openland

Table 4. Habitat types of common species in immature stages with references. (T: Exclusively terrestiral, Ta: Mainly terrstrial, A: Exclusively aquatic At: Mainly aquatic),

Species	Habitat types	References
Ha. tristis	In leaf mold or soil at forest floor (T)	Inaoka *et al.* 1973, Hayakawa *et al.* 1975
T. iyoensis	Under moss on rotten wood or stone, under fallen leaf layer or in soil at forest floor, (Ta).	Saito 1965, Otsuru *et al.* 1965, Kamimura *et al.* 1972, Hayakawa 1972, Nagashima *et al.* 1973
T. sapporoensis	In wet soil along streams, under moss on rock poured by splash from water fall in mountainous region (At).	Saito 1965, Otsuru *et al.* 1965, Nagashima *et al.* 1973
C. suavis	In wet soil at pastures, paddy fields and stream sides, especially near dead water (A).	Watanabe 1969, Hayakawa 1970, '72, Inaoka *et al.* 1973
T. kinoshitai	Similar to *C. suavis* but faily abundant along running water (A).	Hayakawa 1970, '72
T. sapporoenus	In wet soil along or in streams (A).	ditto
T. chrysurus	Similar to *T. sapporoenus* (A)	ditto
T. trigeminus	In wet soil at various habitats, especially abundant in paddy fields (A).	Saito 1965, Otsuru *et al.* 1965, Hayakawa 1970, '72
T. rufidens	In relatively dry soil or leaf mold at forest floor (T)	Hayakawa 1970, '72
T. fulvimedioides	Similar to *T. rufidens* (T)	ditto
T. nipponicus	Widespread from wet to dry soil at various habitats especially abundant at pastures (Ta).	Kato *et al.* 1965, Hayakawa 1970, '72, Inaoka 1971, Inaoka *et al.* 1973
A. horvathi	Widespread, relatively abundant at pastures and paddy fields (Ta).	Hayakawa 1970, '72
C. vanderwulpi	Similar to *C. suavis* (A).	ditto

habitats in Hokkaido though not much abundant in most cases. But the former species is found as a predominant one in rural and urban areas in Honshu (Otsuru *et al.* 1956 and Yamagata *et al.* 1975).

Some species such as *Ha. tristis, Hy. distinguenda, Hy. tarandina, Hy.* sp. and *T. fulvimedioides* are recorded so sporadically in Honshu that their habitat preference there cannot be compared with the results obtained in the present paper.

Thus the habitat preference in Hokkaido and Honshu is similar in most species with notable exception, *T. trigeminus*, which is eurytopic in Hokkaido, while showing a definite preference for openland habitats in Honshu.

However, the distribution and habitat preference of tabanid species cannot be interpreted by the relative abundance obtained by female adult collection alone. Considering the long duration of immature stages, lasting one to three years, and the poor dispersal ability, the habitat in these stages must not be ignored though it is ultimately determined in part by ovipositing behavior of adult females. Table 4 presents the immature habitats of well studied species cited in the present paper, and the relation between adult and immature habitats is schematized in Fig. 7.

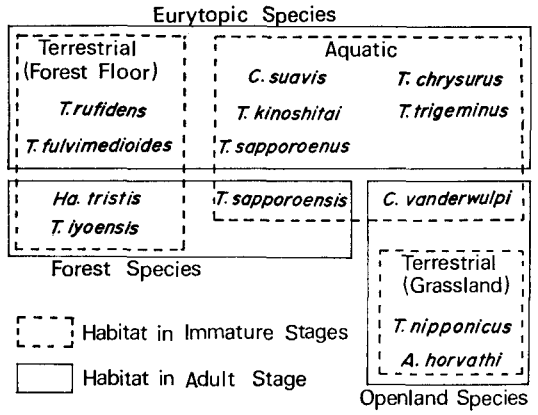

Fig. 7. Relation between immature and adult habitats of well studied species.

The habitats of immatures do not entirely correspond to those of adult female, but some interesting trends are pointed out. Among four terrestrial species living in the forest floor, *Ha. tristis* and *T. iyoensis* are forest species in adult stage, other two species *T. rufidens* and *T. fulvimedioides* are eurytopic. Most species being aquatic in immature stages are seemingly eurytopic except *T. sapporoensis* and *C. vanderwulpi*. The larvae of the former species is mainly found at the mountainous streams and adult seems relatively prefer forest habitat. On the other hand, the latter species lives in the wet soil in sunny places and rather prefers openland habitats in adult. All terrestrial species mainly living in grassland prefer openland habitat in adult stage. Generally speaking, the species with terrestrial mode of life in immature stages show distinct preference for the habitat while aquqtic species are mostly eurytopic. It is quite conceivable that the abundance of species in a given locality is strongly influenced by the area of the habitat where larvae and pupae live. From this point of view, the remarkable abundance of *Ha. tristis* and *T. iyoensis* in forest habitats are easily understood. The abundance of *T. nipponicus* in Hokkaido and *T. trigeminus* in Honshu are probably related to the recent extension of pastures and paddy fields respectively. If this assumption is correct, these species must have increased as a consequence of the human interference. In my opinion, the predominance of *T. nipponicus* at openland habitats in Hokkaido is an outcome of an intensified ruralization started only about 100 years ago. Before that time the larval habitat of *T. nipponicus* must have been confined to the limited areas where the development of forests was edaphically inhibited, for instance, the banks of the rivers receiving frequent floodings. On the other hand, *Ha. tristis* must have dominated throughout the vast forests. In other words, the tabanid assemblage with predominance of *Ha. tristis* has been replaced by that with predominance of *T. nipponicuus* in cultivated areas in Hokkaido. The collection data of horse-flies at the dawn of cultivation is virtually absent so

that the crucial evidence of such alternation is not available. However, there is an incomplete record favoring this assumption, the data obtained at the area developed in Nipesotsu, Tokachi Province in central Hokkaido. The cultivation in this locality began in 1944 and the first survey of insect fauna was made by the members of Entomological Institute of Hokkaido University from July 27 to August 11, 1946. Seven horse-fly species collected are *Ha. tristis*, overwhelmingly predominant (Sakagami pers. comm.), *T. sapporoensis*, *T. chrysurus*, *T. rufidens*, *T. kinoshitai*, *T. fulvimedioides* and *C. suavis*, all belonging to forest or eurytopic species. Twenty-eight years after the first survey, horse-flies were collected by myself on August 16, 1974. *Ha. tristis* was still predominant but *T. nipponicus*, a typical openland indicator not recorded previously, was collected as the second ranked species, followed by *T. chrysurus* and *C. suavis*.

Summary

1) Based upon the female adult collection, seventeen horse-fly species relatively abundant in Hokkaido are classified into three groups according to their habitat preference. Forest species: *Haematopota tristis* Bigot, *Tabanus iyoensis* Shiraki, *T. sapporoensis* Shiraki, *Hybomitra tarandina* (Linne) and *Hy.* sp. Eurytopic species: *Chrysops suavis* Loew, *T. kinoshitai* Kôno et Takahasi, *T. sapporoenus* Shiraki, *T. chrysurus* Loew, *T. trigeminus* Coquillett, *Hy. distinguenda* (Verrall), *T. rufidens* (Bigot) and *T. fulvimeiodides* Shiraki. Openland species: *T nipponicus* Murdoch et Takahasi, *T. pallidiventris* Olsoufiev, *Atylotus horvathi* (Szilady) and *C. vanderwulpi* (Kröber).

2) As to the relation between larval and adult female habitats, it was shown that most species with terrestiral immature stages are relatively stenotopic in adult stage while the species with aquatic larval stage are mostly eurytopic in adult.

3) It is suggested that the tabanid assemblage in Hokkaido is gradually changing from the forest-eurytopic species complex with the predominance of *Ha. tristis* to the openland-eurytopic species complex with the predominance of *T. nipponicus* in parallel with the advanced ruralization.

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